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The Possibility of Replacing Visual Sense with Tactile Sense in the Spatial Representation of the Blind

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ABSTRACT

The paper studies the possibility of replacing visual sense with tactile sense in the spatial representation of the blind. Subjects of the study come from Chiming Senior High School in Taiwan (eleven persons) and regular colleges (five persons), totaling sixteen in all. Their visual conditions are classified into: congenitally blind with no light sense (six persons), congenitally blind with light sense (five persons) and acquired totally blind (five persons). The drawing task focused on real-life object and sketch model. The 84 drawings were classified based on the spatial representation development stage of the blind proposed by I and Shiu (2001) and Kennedy (1984). Results show that visual condition and age both have influence on spatial representation of the totally blind. The spatial representation development of the totally blind continues even beyond 18 years of age, while the development of most of the sighted is stable. The results show that insufficiency of visual conditions delays the spatial representation development of an individual, yet does not terminate the spatial representation development of the totally blind. However, tactile sense does not offer enough spatial messages for spatial representation. Thus, the totally blind are limited and they fail to naturally adopt any advanced projection system. Education, drawing experience and the motivation of drawing are all key factors that enhance spatial representation of the totally blind.

Introduction

In the realm of children drawing development research, spatial representation development has always been the most crucial issue. Drawing research of the blind has gradually caught scholars' attention in recent years. Among the researchers who proposed clear definitions for drawing development stages of the blind is Kennedy's discourse of the six developmental stages (Kennedy, 1984). The other is I and Shiu's theory of the five developmental stages (I & Shiu, 2001). The two groups provided different observations and descriptions toward drawing development of the blind. They also have different opinions in the graphic information obtained through tactile sense in spatial representation development.

Although some researchers (D'Angiulli & Maggi, 2003) claim that drawing development is inborn, its foundation lies in children's knowledge of space and perceptual principles. However, it is still under debate whether tactile sense can replace visual sense to provide key spatial information for the blind to successfully transmit three-dimensional objects to a plane through visual expression even without learning projection systems or representation strategies. The following is a discussion of the two discourses and their possible influences on education.

Tactile Sense Can Replace Visual Sense

Kennedy (1984) categorizes more than 700 drawings of the blind into six categories, from which he proposes six drawing developmental stages. (1) List drawings: using respective marks to indicate composing elements in the environment. Connection of the elements is based on the creator's definition. (2) Outlined separate features: drawing the objects' respective contour features, but connection yet to be established. (3) Connected features: drawing the objects' features, with the sidelines of the surfaces all connected. (4) Vantage point: drawing object features using vantage point. (5) Metaphoric drawings: breaking off the representation of previous stages and proposing indirect implications. For instance, curved lines of a flange are used to symbolize a rolling wheel. (6) Diagrammatic drawings: lines do not only represent the contours of an object but also present a specifically-represented characteristic. For example, thick lines suggest strength; converging lines indicate protrusion of an object. Not only can the contour sideline be drawn out but also the reference proportions. Thickness can be expressed with modifying lines.

The subsequent research of Kennedy (1984) justifies the developmental stages summarized above through reactions of the sighted. Research shows that Stages Four, Five and Six are comparatively unpredictable than Stages One, Two and Three. Nonetheless, Kennedy believes that similar instability also exists in related research on spatial representation developmental stages of the sighted. Due to the fact that sighted children identify with the sequence of the stages, Kennedy claims that the six developmental stages can be applied to the drawing representation stage of sighted children. Kennedy thus proposes the discourse as follows: tactile sense can replace visual sense and the former enables the blind to draw common depth cues frequently used by the sighted. However as the 1983 research shows, the two claims above fail to explain such important details as visual deficiencies, education, topic content and drawing methods.

In addition to research on spatial developmental stages, Kennedy's numerous researches on the blind's ability to express monocular static depth cues continue to justify the discourse mentioned above. He discovers that a congenitally blind with no drawing experience and observation (no light sense after 16 years of age) is able to draw a trapezoidal surface and the two converging legs of the table in the near end. The two legs of the table converge to the top and merge into one point high up. Several adults who are totally blind with and without light sense can represent oblique surface leaning toward the far end with convergent lines. They can also use thick and thin boundary lines to differentiate far and near (Kennedy, 1983). Moreover, the use of convergence among the blind of different regions (Kennedy, 1993) has considerable correlation with relative distance.

A recent study conducted by Kennedy (2003) shows that a 12-year-old blind girl, Gaia, who lost her sight at a young age, is able to adopt such spatial representation strategies as partially occlusion, parallel projection and inverse projections. Another case (Kennedy & Juricevic, 2003) is a 40-year-old woman, Tracy, who lost sight early in life. She is able to draw near oblique projection cubes. Tracy can also use size to represent far and near and up-down left-right precise relative positions often used by the sighted to represent different objects in space. The latest study of Kennedy (Kennedy & Juricevic, 2006) shows that a totally blind 47-year-old male, Esref, can adopt such spatial representation strategies used by the sighted as foreshortening, parallel projection and front-back covering. According to the above studies, Kennedy and some other scholars (Kennedy 2003, 1993, 1984, 1983, 1980; Kennedy & Juricevic, 2003) claim that tactile sense can offer the same spatial principles to allow the blind to have intuitive comprehension perspective and draw planes to represent three-dimensionality.

Tactile Sense Fails to Replace Visual Sense

Researchers who argue against the above studies discover that with strict exclusion of visual experience and visual condition, no matter if the blind draws a simple cube, a cylinder, or even a complex polyhedron, the final developmental stage of a blind differs much from that of the sighted (Hiroshi, 1955, cited in Yasumasa, 1983; Shiu, 1999; I & Shiu, 2001). Moreover, the totally blind cannot comprehend advanced projection system from tactile pictorial drawings.

The studies conducted by Shiu (I & Shiu, 2001; Shiu, 1999) classified 108 drawings into different categories. The drawing assignments include simple geometric objects, partially covered objects sketch, spatial imagination and portraits. The researchers discover that excluding any visual experience, the spatial representation development of the totally blind with no light sense has five stages: (1) disordered non-differentiation space, (2) local feature representation, (3) climax of differentiation, (4) refinement and (5) unity of the whole. With tactile sense alone, the sequence of differentiation and refinement of spatial representation development is similar to what I (1995) proposes of the spatial representation development trend of sighted children. However, representation strategies, developmental final stage, development pace and routes are all different.

The representation feature of the fifth stage, "unity of the whole", is the entire spatial relationship going toward reasonable unity, which allows different viewpoints to be in conformity with one another. An obvious and reasonable direction, length and concept of proportion are in existence. Heading towards a simple representation, the drawing lacks details, leaving only the most typical and basic features to represent a complete structure. In the overlapping assignment, two objects are correctly linked in the drawing. Although a base line is beyond limitation, a representation of two objects standing on the same surface facing the observer is achieved. In this stage some participants continue to use transparent overlapping drawing to replace partial occlusion to retain the complete form of the object. Due to the visual deficiency, representation of spatial relationship among objects of the totally blind is yet to be fully developed. The blind still use individual geometric objects representation in the intelligent realism stage of the sighted, and not the visual realism stage. Meanwhile, the representative characteristics shown in Kennedy's last three stages, i.e. "vantage point", "metaphorical drawing" and "illustration drawing," cannot be found in the picture. Factors that contribute to the disparity may include different visual conditions, age, assignment content, etc.

In addition, I and Shiu (I & Shiu, 2001; Shiu, 1999) also claim that non-visual experience participants prefer such spatial representation strategies as "mixed viewpoints", "unconnected local features", "connected local features" and "ideal viewpoint". The first three may appear simultaneously, consisting of the common representation features in the second to fourth stages. "Ideal view point" appears steadily in the fifth stage. When it comes to the representation of an individual object, orthographic projection is adopted. In terms of cubic representation, orthographic projection is commonly used by 7-year-old sighted people. However a more advanced projection system will replace the system when participants reach age 7 years and older. Apparently between tactile sense and visual sense, only partial object depth information can be shared.

The Influence of Education and Learning

However, scholars have later discovered: faint light sense or visual experience early in life and education will benefit the congenitally blind's drawing representation. I and Shiu (2001) discover: through education, a congenitally blind with no light sense can interpret square cubes drawn by adoption of oblique projection in his observation assignment. The researchers explicitly conclude that the outstanding blind participant is putting himself in the shoes of the sighted. His performance outshines all other participants. Hiroshi also discovers that 17-to-28 year-old congenitally blind people cannot comprehend the perspective projection of the sighted. Yet if visual image principles were taught in the first place, (e.g., a circle turns into an oval, a square turns into a trapezoid) the congenitally blind can completely answer what models the sighted has drawn (Hiroshi, 1955, cited in Yasumasa, 1983). In addition, many of the outstanding participants (e.g., Gaia, Tracy and Esref) in Kennedy's research have a great passion for drawing and have acquired much knowledge about drawing strategies and projection system principles used by the sighted. The above cases indicate that learning plays a crucial role in the totally blind's spatial representation.

Heller (2002) believes that the blind possesses sharp art identification abilities. However, their comprehension may not be the same as that of the sighted. The congenitally blind are slow in development in terms of Piaget's theory, i.e., in retaining numbers and volumes. Without special tactile experience learning, their spatial concept of direction and position will be fairly vague (Cahill, Linehan, McCarthy, Boremans & Engelen, 1996; Thomas & Evelyn, 1997). Dulin also believes that tactile drawing comprehension is not inborn. Projection principles of the learning drawings, the optimization of touch and haptic exploration processes must all complement with tactual pictures when learning to draw (Dulin, 2007). The congenitally blind and blind children who lose their sight early in life are slow in their spatial development. Such can be improved through tactual drawing education (Dunlin, 2007; Dunlin & Hatwell, 2006). The above studies all justify the importance of education in spatial representation development.

Conclusion

The disparity that lies in the drawing development theory is a set fact. Whether "tactile sense can replace visual sense to provide enough visual information" is still under much debate. If the above questions can be answered, then such gaps can be bridged. Do remnant faint sense and visual experience early in life play an important role in the totally blind's spatial representation development? How have education and learning changed the totally blind's spatial representation? These are issues yet to be clarified.

In view of the above, this paper aims to achieve the following goals:

a. Compare the spatial representation development differences among totally blind with different visual conditions.
b. Discuss the possible influence of education on the spatial representation development of the totally blind.

It is to clarify the influence of visual condition and education on the totally blind's spatial representation development. In addition, observations of the totally blind aged 18 and older is attached, including the influence of different stimulus.

Methodology

Participants

Due to the fact that visual conditions are strictly controlled in this research, multi-handicapped blind people are excluded in order to reduce the interference of unknown factors. For that reason, participant who comply with all set conditions are few. The 11 high school participants all come from a school for the visually impaired in Taipei. The school is the only one in Northern Taiwan. Almost all the students who meet the criteria have participated in the research. However, some of the blind were excluded from our research because they attended regular schools and were scattered in different places. The five college students all come from the university of Taipei Resource Center for the Visual Impairment. All participants agreed to join voluntarily. According to different visual conditions, they are classified into the following: congenitally with no light sense (six persons), congenitally blind with light sense (five persons) and acquired totally blind (five persons) (See Table 1).

Instruments

Instruments used are drawing tools invented by the researchers, including the clay board and drawing pencils that enable the blind to touch-read instantly and make revisions easily. The clay board is made of clay specially used for sculpture, which is formed into a tablet of A4 (210 mm. × 297 mm.) in size and 5 mm in thickness. In addition, participants were provided with two different kinds of drawing pencils. The size of the clay tablet is designed to allow participants to draw conveniently the stimulus in 1-1 proportion.

Table 1. Basic information of the participants

Group	Participant ID	Age	# of drawings	Age of vision lost	School/Grade
Congenital total blindness without light perceptions	CB01	19(19;1)	8	0	College/1st
	CB02	19(18;9)	7	0	School for VI/11
	CB03	19(18;9)	4	0	School for VI/11
	CB04	19(18;8)	3	0	College/1st
	CB05	18(18;1)	5	0	School for VI/12
CB	CB06	18(17;12)	5	0	School for VI/11
Sub-total	n＝6	M=18.6 (18;06)	32	0	
Congenital total blindness with light perceptions	LP01	23(23;3)	5	0	College/2nd
	LP02	22(21;10)	7	0	College/4th
	LP03	20(19;6)	4	0	School for VI/13
	LP04	20(19;6)	5	0	School for VI/10
LP	LP05	18(17;11)	4	0	School for VI/10
Sub-total	n＝5	M=20.6 (20;4)	25	0	
Acquired blindness **AB**	AB01	20(19;10)	6	Congenital glaucoma at the age of 1; total blindness at the age of 14	College/2nd
	AB02	19(18;10)	6	Past visual impairment on the right eye; total blindness at the age of 10	School for VI/11
	AB03	19(18;9)	4	Past visual impairment; total blindness at the age of 12	School for VI/11
	AB04	19(18;6)	7	Past visual impairment; total blindness at the age of 11	School for VI/12

	AB05	19(18;6)	11	Congenital retina pathology; total blindness at the age of 10	School for VI/11
subtotal	n＝5	M= 19.2(18;10)	27		
Total	N＝16				

*Note: the numbers in the age column represent the participant's AGE (YEAR; MONTH). For example, "19 (18; 10)" means the participant's age is 19 after rounding, and the actual age is 18 years and 10 months. The "M" value represents the mean age of each group.

Stimulus

In current studies of drawings by the blind, simple geometric forms, tables and house models are often used as stimulus. In this research, we have adopted stimuli with a rather complex form. The stimuli can be classified into two: models of the same size (including apples, carambola, green pepper, mugs and balls) and models of a shrinking size (including pipe organs, buildings and airplanes).

Procedures

The research process was as follows: (1) Researchers explained the goal of the research and how the drawing assignment was conducted. The participant were given real object models. (2) Researchers provided drawing tools and explained the drawing process and revision. (3) The participants were made familiar with how the tools were utilized. (4) The participants performed the drawing assignment. Clay boards were provided as many as needed by participants. The assignment was conducted with much flexibility on the basis of participants' performance. If participants thought that the task was difficult, then the level would be decreased by replacing with a lower-level model. If the opposite was true, the level of the assignment would be increased and a complex model would be offered. There were no time limits. If participants expressed little interest and intention in drawing, the research would be terminated. The entire process was videotaped using digital cameras and camcorders.

Method of Analysis

Drawings analysis was based on the studies of I and Shiu (2001) and Kennedy (1984) in regard to the spatial representation development of the blind. Researchers served as classifiers. The classification process included: (1) Definition and familiarization with the typical drawing of each stage and a review of the participants' drawing process. (2) Two researchers conducted separate classifications independently. (3) The classification results of the two researchers were compared and the difference in classification was discussed until a consensus was reached. (4) When a difference emerged within the classification, two researchers evaluated participants' spatial representation style again and reviewdd the video recording of the drawing process as a basis for judgment.

Results

The research results contain a total of 84 drawings. After digital image preservation and analysis, we arrive at the results as follows:

Speculation of the Two Spatial Representation Development

Taking the spatial representation development of I and Shiu (2001) as basis, participants' drawings are roughly in the fourth and fifth stages. Nine participants even exceeded the "unity as a whole" (fifth stage), including the congenitally blind with no light sense (one person), congenitally blind with light sense (three persons) and acquired totally blind (five persons). Only one congenitally blind with no light sense appears in Stage Four. The results of the study are mostly in the fourth and fifth stages. No single participant lags behind Stages One to Three. Moreover, some of them exceeded Stage Five. This phenomenon shows that the totally blind aged 18 years and older can keep on improving spatial representation. As far as spatial representation features are concerned, the connection between the relative position and the object segments comes into the picture in Stage Four. In Stage Five the object segments display a reasonable spatial representation. In addition, due to the rise of the difficulty level in the object form, drawings of the totally blind show a more exquisite representation such as detailed descriptions of the use of oblique lines, surface protrusion and texture. This presentation strategy does not emerge in the simple geometric object assignments of the totally blind aged under 18 in I and Shiu's research (I & Shiu, 2001).

Take Kennedy's six-stage (Kennedy, 1984) discourse as an example. Two totally blind with no light sense appear in Stage Three. Two acquired totally blind appear in Stage Four. Four congenitally blind with no light sense, five congenitally blind with light sense and three acquired totally blind appear in Stage Six. Results show that the congenitally blind (with or without light sense) does not represent objects by using the "vantage point" of Stage Four. Stage Four spatial representation is similar to that of Luquet's visual realism, which is merely adopted by the acquired totally blind. Visual experience is the determining factor that contributes to the difference. In addition, the "illustration drawing" of the final stage was achieved by 12 participants with different visual conditions. Stage Five does not come into picture.

In summary, participants of the research mostly scatter among the fourth and fifth stages defined by I and Shiu (2001), which shows that a sequence order exists between these two stages. Three totally-blind groups of different visual conditions all entered the fifth stage, which shows that the classification is also suitable for the totally blind of different visual conditions. When the assignment difficulty level is heightened and participants' age limit is extended to 18 years and older, three groups of participants all drew spatial representation features that exceed what is in Stage Five. This shows that the definition of the spatial representation in the fifth stage can be extended further. However, analyzing with Kennedy's six-stage discourse (Kennedy, 1984), only stages three, four and six emerged. The development sequence order is not consistent as that of the previous result. The probability of the emergence of Stage Four has a lot to do with visual experience. Studies show that Kennedy's six-stage theory is not stable, and is liable to intervention by visual condition.

Representation Features

As far as representation features are concerned, in the third and fourth stages of each assignment, simple lines or forms are commonly used to represent an object. For instance, in the carambola assignment, we observe that the totally blind stresses more the crest line description of a carambola. Line combination of different length is used to represent carambola as well. The typical examples are CB02 (18; 9), LP04 (19; 6), LP02 (21; 10) (See Figure 1-4). Comparing with the drawing development of the sighted, such presentation strategy is similar with what Golomb (1992) describes as "consisting of global units". Golomb indicates that sighted children will represent animal and human subject drawings by using a surface feature combination. For example, the combination of a vertical line and many horizontal lines on top is to represent a giraffe. A near circle with spiral short lines on its rim and two small circles within the circle are to represent a kitten.

Such eerie and unique combination of circles, lines and dots are not part of the existing sensual mode. Instead, the children invented the representation system themselves (Golomb, 1992). The strategy is a representation of a 3-year-old sighted, but is often adopted by the congenitally blind with and without light sense aged 18 to 21 years and 10 month old. The difference resulting from lack of visual experience is evident here.

Figure 1.
CB02 (18; 9), the first drawing of a green pepper by CB02.

Figure 2.
CB02 (18; 9), the second drawing of a green pepper by CB02.

Figure 3.
LP04 (19; 6), drawing of a carambola.

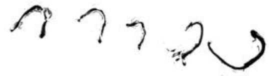

Figure 4.
LP02 (21; 10), drawing of a carambola.

Complexity of the Stimulus: Taking the airplane assignment as an example

Regarding the formal complexity of an object, when the form is rather simple in nature, the congenitally blind with no light sense will use single round mass or a closed or round curve to represent the object. When the form is rather complex, sometimes they will place respective features of the object in the drawing separately (See Figure 1, 2 and 5), with each having no correlations with the others. In the representation of object features, the congenitally blind with light sense display much exquisite description of details (See Figures

6 and 7). When it comes to a more complex object, most of them can connect different features into one single object. However, a few fail to establish the relationship among different features. They place such features in perpendicular or parallel order to represent respective features in the drawing (See Figures 3 and 4). The phenomenon shows that when faced with an object with more complex features, before finding reasonable connection strategies among different elements, some congenitally blind with and without light sense will adopt layer representation to represent the object. In addition, the acquired totally blind's spatial representation far exceeds the above two groups, especially in expressing the difference among different features. Moreover, acquired blindness (AB) did best among the three groups in the spatial connection. Comparing with the other two groups, they often use accurate proportional closed contour to represent object segments (See Figures 9-12). Thus, they can represent the difference of an object using different forms. The above phenomenon shows that visual condition has great influence on spatial representation.

Figure 5.
CB01 (19; 01), drawing of an airplane.

Figure 6.
LP02 (21; 10), drawing of an airplane.

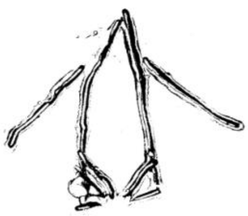

Figure 7.
LP01 (23; 03), drawing of an airplane.

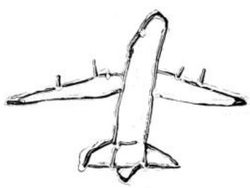

Figure 8.
AB01 (19; 10), drawing of an airplane.

Projection System

As far as projection system is concerned, no linear perspective has been adopted in the drawing results. Of all the 84 drawing assignments of the totally blind, only 3 acquired totally blind adopted the oblique projection system to represent glasses (AB04, 18; 06) (See Figure 9), apples (AB03, 18; 9) (See Figure 10) and green peppers (AB01, 19; 10) (See Figure 11). One acquired totally blind adopted near oblique projection to represent a mug (AB03, 18; 9) (See Figure 12). The other 80 drawings show no intention of representing using near oblique projection or oblique projection, or even, the perspective projection system. Not one of the congenitally blind—with or without light sense—shows near oblique, oblique projection or perspective. The phenomenon shows that past visual experience seems to be the determining factor of whether near oblique or oblique projection come into play. The congenitally blind do not naturally develop perspective. Such a finding concurs with those of I and Shiu (2001).

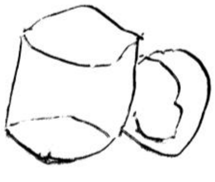

Figure 9.
AB04 (18; 6), a mug.

Figure 10.
AB03 (18; 9), an apple.

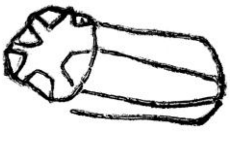

Figure 11.
AB 01(19; 10), a green pepper.

Figure 12.
AB03 (18; 9), a mug.

Education, Drawing Experience and Motivation

The study discovered that education, drawing experience and individual's learning attitude have a huge influence on the blind's spatial representation. In the group of congenitally blind with light sense, LP01 (23; 03) encountered a mathematics teacher in junior high school where he was taught trigonometric function and different mental rotation of the object in three dimension through numerous raising line drawings. Therefore, LP01 could precisely draw the orthographic projection of every object and orthographic projection after object rotation. Moreover, he expressed his strong intention to represent object depth. For instance, he attempts to use a curve or oblique lines to express thickness. Although after many attempts he still failed to draw the stimulus of oblique projection, his performance was well beyond the spatial representation of the following case, CB04.

In the group of congenitally blind with no light sense, CB04 (18; 08) has been taught with the notion that " a blind does not need to learn how to draw and he or she does not know how to draw". Therefore she puts great time and effort in learning languages (French) and music (piano). When asked to draw, she felt much troubled. She said drawing three-dimensional objects on a two-dimensional plane is mission impossible. Although the researchers kept encouraging her for as long as eight hours, CB04 still rejected to try out a different way of drawing. She always used the simplest orthographic projection and unchanged pan-circle to represent pan-sphere stimuli (e.g., apples, peaches, bells). When confronting different stimuli, she rejected to give any answer. She showed no intention of representing depth and no interest in drawing.

The other five congenitally blind with no light sense had little experience in drawing. They expressed their difficulties at the beginning, but with researchers' encouragement they gradually discovered solutions to their assigned topics and developed more confidence in drawing. This example shows how important education is.

In the group of the acquired totally blind, two individuals stood out from the rest. AB01 (19; 10) took a positive learning attitude when faced with challenges. AB04 (18; 06) had a great passion for and much experience in drawing before becoming blind. That explains the reason why the two performed better than the rest.

AB01 (19; 10) kept a high interest and strong motivation in the entire drawing process. When researchers gradually raised the difficulties of the assignments, he could always complete the task fast and with much confidence. The lines he drew were so smooth that it was hard to believe it was his first drawing task. When AB01 was drawing the pipe organ, he did mention his experience of touching a pipe organ before. He hoped that one day he could play the pipe organ at the church. That is why he was able to draw the pedals that were not shown in the model (See Figure 10). When researchers asked him to draw a dog with an iron leash, he mentioned his liking for mastiffs. In his childhood there were many mastiffs to play with him in his grandfather's house. Under the request of the researchers, he drew the mastiff by memory – one with a pair of long-standing ears and furs and long nose (See Figure 13). From his drawings we can observe that AB01 can accurately express the spatial representation relationship of the object and further express his observations and inclinations toward subjects based on his own life experience. Besides his faint visual experience, both the motivation in drawing and positive attitude contributed to his performance.

Figure 13.
AB01 (20; 10), he drew the pipe organs (left), and the mastiff by memory (right).

The other individual, AB04, loved drawing before he lost his eyesight, but stopped drawing after he became blind. When researchers asked him to draw, he pleasantly inquired where to buy related material to continue drawing. His speed in drawing was fast and he could use oblique projection system to represent a mug. When researchers asked him to draw a human subject, he mentioned his passion for the cartoon "Dragon Ball" before becoming blind. Eventually he relied upon his past visual memory to quickly draw the comic figures he saw in childhood. Such a result shows the influence of visual and drawing experience before losing one's eyesight (See Figure 14).

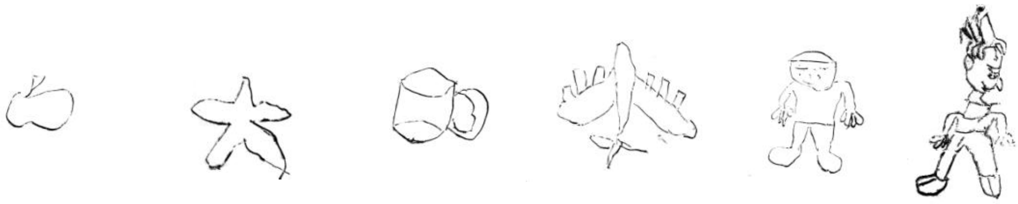

Figure 14.
AB04 (18; 06), he drew an apple, a carambola, a mug, an airplane, a person and the cartoon character "Dragon Ball".

From the cases above we can conclude that education, motivation and past visual and drawing experiences before losing sight can all enhance spatial representation of the blind.

Discussions

From a developmental perspective, we have a rather pessimistic finding for the spatial representation development of the totally blind. With strict exclusion of any visual experience, we still fail to justify that tactile sense can replace visual sense and acquire enough or similar pictorial information. Therefore, visual condition apparently contributes to difference in spatial representation.

However, while we overturn Kennedy's rather optimistic views toward the development, two reasons can still explain the different results of the two studies with the exclusion of the major influence sight has on the issue of participants. (1) The disparity between the two studies results from difference in learning and motivation. (2) The research subjects of

Kennedy's are exceptional. Thanks to the special congenital conditions, they possess excellent spatial representation skills. Their accomplishments cannot represent the totally blind in a universal sense.

The first suggests the influence of environment and indicated the importance of education and learning. Besides individual development, there is much room for improvement in terms of the blind's spatial representation. Participants of the research, along with those of I and Shiu's study (I & Shiu, 2001), hardly ever had any chance for drawing. Western societies pay more respect to the blind and have abundant resources on pictorial learning. Family and school education shows a supportive and encouraging attitude toward the blind. The individual's personal interest and motivation also differs from person to person. Such external influences may explain the reason why the totally blind in this study failed to develop perspective.

In the Taiwanese education for the visually impaired, subjects that rely upon hearing such as music is emphasized. Art-related courses are often categorized as visually-related and are often neglected. Most teachers and parents are unclear about and do not pay much attention to tactual art sense and the related representational experience. Even in formal special education, sculpture, raising line drawing, printmaking and ceramic art are not offered to students. However, the most crucial goal of education for the blind is to shorten the gap between the sighted and the visually impaired. It is best for the blind to acquire as much experience as possible, but it must not preclude the possibility of pictorial creation and communication.

We believe that visual condition is the key to what projection system the blind adopts to represent space. Furthermore, education can definitely enhance individuals' motivation of representation and presentation strategy. However, whether education can help the blind of different visual conditions to attain the perspective or oblique projection as mentioned in Kennedy's research is yet to be determined. This issue obviously requires more research and effort. After all, the perspective image of an object comes from the projection of the retina. When three-dimensionality is projected into two-dimensionality, except for some specific angles, the transformation usually distorts all physical features of the object (e.g., size and angle). Whether education can teach the blind to comprehend such distortion through tactile sense and represent the distortion have yet to be proven. However from an educator's perspective, Kennedy's finding is still quite encouraging, for such a discovery makes us take an optimistic attitude toward art education for the blind.

To sum up, the spatial representation development of the totally blind, aged 18 years and older, is still in progress. The drawing representation strategies and developmental stages of the blind and the sighted share some common characteristics. Such similarities can only justify the fact that visual experience is not a necessary condition for drawing representation. However, differences in individual visual conditions and experiences all contribute to the great disparity in the final development of spatial representation, developmental speed and representation strategies. They result in the disparity of the pictorial features between the sighted and the blind. Individual drawing experiences and personal motivations will help close the gap. Therefore, educators of the blind, art educators, parents and the blind themselves should take a more open-minded and positive attitude toward pictorial art education.

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